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EFFECT OF COMPOST AND SOME ANTIOXIDANT TREATMENTS ON OIL PRODUCTIVITY AND SOME CHEMICAL CONSTITUENTS OF *MELISSA OFFICINALIS*

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ABSTRACT: This study was undertaken over the two growing seasons of 2021/2022 and 2022/2023 at the Nursery of Ornamental Plants, Fac. Agric., Minia Univ., Egypt, with the aim to investigate the effects of compost and various antioxidants, including amino acids, seaweed extract, and vitamin E, on the oil productivity and certain chemical constituents of *Melissa officinalis*, L. Data revealed that all studied parameters i.e., essential oil percentage and yield per plant per cut were significantly increased with fertilizing plants with compost relative to control through the three cuts during both seasons. Moreover, all the aforementioned parameters were elevated from 1^{st} cutting to 3^{rd} one. Additionally, the yield of essential oil per season per plant or per feddan, along with the contents of chlorophyll a, b, and carotenoids in the fresh leaves and N, P, K % in the dry leaves were noticeably increased with compost fertilization (at the three levels). The highest values were obtained from 12 ton/fed compost, followed by 8 ton/fed compost. In many instances, there were no substantial distinctions among themselves. The application of amino acids, sea algae, and vitamin E, each at specified concentrations, resulted in a notable enhancement of all previously mentioned parameters when compared to the control group across both seasons. In this regard, vitamin E at a lower concentration (100 ppm) demonstrated particularly superior effects. The best interaction treatment was to supply plants with compost at 12 or 8 ton/fed and spray them with vitamin E at 100 or 200 ppm or sea algae at 3 ml/l to obtain the highest essential oil percentage and yield per plant and per feddan of *Melissa officinalis*.

Keywords: *Melissa officinalis*, amino acids, vitamin E, sea algae, oil production

INTRODUCTION

Lemon balm (*Melissa officinalis* L.) is a well-recognized perennial herb that is herbaceous in nature. Although it originates from the Mediterranean area, it is grown globally. This plant possesses a significant amount of essential oil, ranging from 0.05 to 0.52%, which is likely accountable for the herb's sedative, carminative, antispasmodic, antibacterial, and antiviral characteristics (Chung *et al*., 2010; Spiridon *et al*., 2011; Abdellatif *et al*., 2014 and Radacsi *et al*., 2016).

Compost is rich in essential nutrients that are vital for plant development, including forms that are readily absorbable such as nitrate, phosphate, magnesium, calcium, potassium, and various other compounds considering that the percentage of elements such as nitrogen and phosphorus are critical for the formation of secondary metabolites like essential oil and its components (Darzi, 2007; Asghari *et al*., 2015 and Bonacina *et al*., 2017).

Antioxidants can be utilized in a range of plant species through several mechanisms that enhance growth, including their direct influence on the native antioxidant chemical and enzymatic systems, increased synthetic capacity or adaptability, and alterations in phytohormone signaling and the metabolism of the applied antioxidants. These compounds are extensively employed in the biosynthesis of a diverse array of non-protein nitrogenous substances, i.e., coenzymes, pigments, vitamins, lipids, and the essential purine and pyrimidine bases, which are recognized as significant biostimulants (Rafiee *et al*., 2016 and de Queiroz *et al*., 2023).

Thus, this research sought to examine the impact of compost and some antioxidants on volatile oil productivity in addition to some chemical constituents of *Melissa officinalis* plant.

MATERIALS AND METHODS

The study was conducted across the two experimental seasons 2021/2022 and 2022/2023 in the Nursery of Ornamental Plants, Faculty of Agriculture, Minia University, Egypt to evaluate the influence of compost and some antioxidants in growth of *Melissa officinalis*, L.

Plant material:

Melissa officinalis seedlings were obtained from the Floricultural Farm, Fac. Agric., Minia Univ. and were transplanted in the field on 1st week of December in both seasons. The physiochemical analysis of the experimental soil was performed according to Jackson (1973) as listed in Table (a).

Layout of the experiment:

The study consisted of 28 distinct treatments arranged in a split plot design, featuring four main treatments (0, 4, 8 and 12 ton compost/feddan) across seven antioxidant treatments (control, amino acids at 1 and 2 ml/l, seaweed extract at 1.5 and 3 ml/l and vitamin E at 100 and 200 ppm), with three replicates for each. The dimensions of the main plot measured 8.70 meters in length and 2 meters in width, accommodating 14 rows, while each replicate covered an area of 8 meters in width and 8.7 meters in length, resulting in a total experimental area of 208.8 square meters. Each treatment unit comprised two rows (6 plants/row), totaling 12 plants. The four compost treatments were designated for the main plots, whereas the seven antioxidant treatments were designated for the sub-plots.

Nile compost, produced from plant materials, was procured from the El-Nile Factory which is situated in New El-Minia City and was utilized during soil preparation across both growing seasons. The physio-chemical analysis of the used compost in both seasons, as indicated on compost label, can be found in Table (b).

Amino acids (Aminogen) contain free amino acids was released from Chema Industries, Egypt. The primary ingredient of

Table a. The physiochemical properties of the used soil in both seasons of 2021/2022 and 2022/2023.

Soil character	Values		Soil character	Values	
	2021/2022	2022/2023		2021/2022	2022/2023
Physical properties			**Nutrients**		
Sand (%)	29.39	29.78	**Total N (%)**	0.77	0.78
Silt (%)	31.37	31.95	**Available P (ppm)**	18.6	19.1
Clay (%)	39.24	38.27	**Na^+ (mg/100 g soil)**	1.33	1.37
Soil type	Clay loam	Clay loam	**K^+ (mg/100 g soil)**	0.87	0.98
Chemical properties			**DTPA-Extractable nutrients**		
pH (1:2.5)	7.85	7.89	**Fe (ppm)**	1.65	1.72
E.C. (dS/m)	1.01	1.06	**Cu (ppm)**	0.42	0.44
O.M.	1.62	1.73	**Zn (ppm)**	0.46	0.49
$CaCO_3$	3.16	3.38	**Mn (ppm)**	0.51	0.54

Table b. Chemical analysis of the used compost in both seasons of 2021/2022 and 2022/2023.

Properties	Value	Properties	Value
Organic carbon (%)	25.1	**Total P (%)**	0.5
Humidity (%)	25	**Total K (%)**	1.0
Organic matter	44	**Fe (ppm)**	1750
C/N ratio	17.5	**Zn (ppm)**	60
pH (1:2.5)	8.0	**Mn (ppm)**	125
E.C. (m. mhos/cm.)	5	**Cu (ppm)**	200
Total N (%)	1.5		

the Algae star product is sea algae extract, which was sourced from Shoura Chemical Company located on the Cairo-Alexandria Desert Road in Giza Governorate of Egypt. Additionally, alpha tocopherol, commonly known as vitamin E, was provided by Sigma Chemical Company based in the United States. The application of all antioxidants occurred on nine separate occasions, specifically three times prior to the initial harvest on the December 20th, the January11th, and the February 2nd; three times before the second harvest on the April 6th, the April 27th, and the May 18th; and three times preceding the third harvest on the July 15th, the August 7th, and the August 28th. Each treatment was administered until the run off. All other agricultural practices were conducted in accordance with standard procedures. The plants were harvested three times during each season, with the cutting taking place 3 cm above the soil level. The three harvesting dates were the March 21st, the July 1st, and the October 11th for both seasons.

Data recorded:

Essential oil (EO) percentage according to Egyptian Pharmacopoeia (1984), yield per plant per cut, yield per plant per season (ml) and per fed/season (l) were calculated. Moreover, the determination of photosynthetic pigments (Fadl and Sari El-Deen, 1979), in addition to N, P and K % (ICARDA, 2013) were performed in the third cut.

Statistical analysis:

The obtained data for all characteristics were systematically arranged into tables and statistically analyzed with the aid of MSTAT–C (1986), subsequently employing the LSD test (at 0.05 significance level) to enable comparisons between the means of the treatments.

RESULTS AND DISCUSSION

1. Oil productivity:

Regardless of the effect of all treatments, data listed in Tables (1 and 2) pointed out that essential oil percentage and yield were the highest in the third cut than in either 1st or 2nd cut. The increase in such parameters in the third cut may be due to the suitable weathering condition and the high yield of dry biomass.

Supplying *Melissa officinalis* with compost at 4, 8 and 12 ton/fed caused a significant rise in EO % and yield per plant per cut facing control through 3 cuts during the two seasons as presented in Tables (1 and 2). The increase in previous parameters were increased with increasing compost level, so, the high values were achieved with 12 ton/fed. Meantime, there were no substantial distinctions among 8 and 12 ton compost per feddan.

It was noticed that the EO yield per plant or per feddan per season was noticeably augmented over the control (Table, 3). Such increase in essential oil yield per feddan per season measured 43.38, 79.56 and 103.35% over the control in the first season. Similar trends were detected in the second season.

Essential oils are composed of terpenoid compounds, which are built from isoprenoid units, including isopentyl pyrophosphate and dimethylbutyl acrylate, and their synthesis requires increasing amounts of ATP and NADPH. The presence of nitrogen and

Table 1. Response of *Melissa officinalis* essential oil percentage to compost fertilization and some antioxidants throughout the three cuttings during both seasons (2021/2022 and 2022/2023).

Antioxidant treatments (B)	Compost fertilization level, ton/feddan (A)									
	0.0	4	8	12	Mean (B)	0.0	4	8	12	Mean (B)
	First season (2021/2022)					Second season (2022/2023)				
	Cut number 1									
Control	0.095	0.100	0.101	0.102	0.100	0.098	0.101	0.103	0.104	0.102
AA (1 ml/l)	0.101	0.104	0.106	0.107	0.105	0.104	0.107	0.109	0.110	0.108
AA (2 ml/l)	0.105	0.108	0.110	0.111	0.109	0.109	0.113	0.115	0.116	0.113
SAE (1.5 ml/l)	0.110	0.116	0.119	0.122	0.117	0.115	0.120	0.124	0.126	0.121
SAE (3 ml/l)	0.116	0.121	0.126	0.130	0.123	0.121	0.127	0.131	0.133	0.128
Vit. E (100 ppm)	0.128	0.135	0.139	0.141	0.136	0.133	0.140	0.144	0.147	0.141
Vit. E (200 ppm)	0.122	0.128	0.132	0.134	0.129	0.127	0.133	0.134	0.136	0.133
Mean (A)	0.111	0.116	0.119	0.121	0.117	0.115	0.120	0.123	0.125	0.121
$LSD_{0.05}$	A: 0.004		B: 0.002		AB: 0.004	A: 0.003		B: 0.002		AB: 0.004
	Cut number 2									
Control	0.099	0.104	0.105	0.106	0.103	0.102	0.105	0.107	0.108	0.106
AA (1 ml/l)	0.105	0.108	0.110	0.111	0.109	0.108	0.111	0.113	0.114	0.112
AA (2 ml/l)	0.109	0.112	0.114	0.115	0.113	0.113	0.118	0.120	0.121	0.118
SAE (1.5 ml/l)	0.114	0.121	0.124	0.127	0.121	0.120	0.125	0.129	0.131	0.126
SAE (3 ml/l)	0.121	0.126	0.131	0.135	0.128	0.126	0.132	0.136	0.138	0.133
Vit. E (100 ppm)	0.133	0.140	0.145	0.147	0.141	0.138	0.146	0.150	0.153	0.147
Vit. E (200 ppm)	0.127	0.133	0.137	0.139	0.134	0.132	0.138	0.139	0.141	0.138
Mean (A)	0.115	0.121	0.124	0.126	0.121	0.120	0.125	0.128	0.130	0.126
$LSD_{0.05}$	A: 0.005		B: 0.003		AB: 0.006	A: 0.005		B: 0.004		AB: 0.008
	Cut number 3									
Control	0.103	0.108	0.109	0.110	0.107	0.106	0.109	0.111	0.112	0.110
AA (1 ml/l)	0.109	0.112	0.114	0.116	0.113	0.112	0.116	0.118	0.119	0.116
AA (2 ml/l)	0.113	0.117	0.119	0.120	0.117	0.118	0.122	0.124	0.125	0.122
SAE (1.5 ml/l)	0.119	0.125	0.129	0.132	0.126	0.124	0.130	0.134	0.136	0.131
SAE (3 ml/l)	0.125	0.131	0.136	0.140	0.133	0.131	0.137	0.141	0.144	0.138
Vit. E (100 ppm)	0.138	0.146	0.150	0.152	0.147	0.144	0.151	0.156	0.159	0.152
Vit. E (200 ppm)	0.132	0.138	0.143	0.145	0.139	0.137	0.144	0.145	0.147	0.143
Mean (A)	0.120	0.125	0.129	0.131	0.126	0.125	0.130	0.133	0.135	0.130
$LSD_{0.05}$	A: 0.005		B: 0.003		AB: 0.006	A: 0.005		B: 0.004		AB: 0.008

Where: AA (amino acids), SAE (sea algae extract) and Vit. E (vitamin E)

Table 2. Response of *Melissa officinalis* essential oil yield (ml/plant/cut) to compost fertilization and some antioxidants throughout the three cuttings during both seasons (2021/2022 and 2022/2023).

Antioxidant treatments (B)	Compost fertilization level, ton/feddan (A)									
	0.0	4	8	12	Mean (B)	0.0	4	8	12	Mean (B)
	First season (2021/2022)					Second season (2022/2023)				
	Cut number 1									
Control	0.020	0.024	0.030	0.034	0.027	0.025	0.028	0.038	0.042	0.033
AA (1 ml/l)	0.025	0.029	0.039	0.042	0.034	0.029	0.039	0.043	0.045	0.039
AA (2 ml/l)	0.029	0.036	0.043	0.049	0.039	0.038	0.046	0.049	0.052	0.047
SAE (1.5 ml/l)	0.033	0.043	0.049	0.056	0.045	0.045	0.052	0.055	0.057	0.052
SAE (3 ml/l)	0.037	0.051	0.059	0.065	0.053	0.051	0.060	0.064	0.069	0.061
Vit. E (100 ppm)	0.051	0.068	0.076	0.085	0.070	0.065	0.099	0.105	0.125	0.099
Vit. E (200 ppm)	0.044	0.060	0.070	0.078	0.063	0.058	0.064	0.072	0.083	0.069
Mean (A)	0.034	0.044	0.052	0.058	0.047	0.044	0.055	0.061	0.068	0.057
$LSD_{0.05}$	A: 0.007	B: 0.005	AB: 0.010			A: 0.011	B: 0.010	AB: 0.020		
	Cut number 2									
Control	0.036	0.045	0.064	0.095	0.060	0.031	0.054	0.075	0.097	0.064
AA (1 ml/l)	0.046	0.086	0.092	0.118	0.086	0.044	0.073	0.085	0.108	0.078
AA (2 ml/l)	0.052	0.102	0.127	0.144	0.106	0.055	0.087	0.124	0.196	0.116
SAE (1.5 ml/l)	0.064	0.117	0.149	0.165	0.124	0.062	0.110	0.178	0.236	0.147
SAE (3 ml/l)	0.077	0.130	0.169	0.184	0.140	0.089	0.140	0.226	0.275	0.182
Vit. E (100 ppm)	0.096	0.167	0.213	0.238	0.178	0.110	0.261	0.281	0.326	0.245
Vit. E (200 ppm)	0.089	0.149	0.189	0.199	0.156	0.099	0.167	0.250	0.292	0.202
Mean (A)	0.066	0.114	0.143	0.163	0.121	0.070	0.127	0.174	0.219	0.148
$LSD_{0.05}$	A: 0.021	B: 0.013	AB: 0.026			A: 0.046	B: 0.014	AB: 0.028		
	Cut number 3									
Control	0.066	0.085	0.085	0.096	0.083	0.068	0.094	0.097	0.134	0.098
AA (1 ml/l)	0.076	0.099	0.097	0.116	0.097	0.094	0.106	0.130	0.142	0.118
AA (2 ml/l)	0.081	0.108	0.118	0.160	0.117	0.119	0.131	0.162	0.188	0.150
SAE (1.5 ml/l)	0.094	0.120	0.142	0.189	0.136	0.160	0.192	0.217	0.227	0.199
SAE (3 ml/l)	0.105	0.132	0.188	0.202	0.157	0.210	0.237	0.252	0.265	0.241
Vit. E (100 ppm)	0.127	0.162	0.240	0.246	0.194	0.268	0.302	0.326	0.342	0.309
Vit. E (200 ppm)	0.116	0.146	0.213	0.219	0.174	0.247	0.276	0.278	0.295	0.274
Mean (A)	0.095	0.122	0.155	0.175	0.137	0.166	0.191	0.209	0.228	0.199
$LSD_{0.05}$	A: 0.021	B: 0.004	AB: 0.008			A: 0.020	B: 0.008	AB: 0.016		

Where: AA (amino acids), SAE (sea algae extract) and Vit. E (vitamin E)

Table 3. Response of *Melissa officinalis* essential oil yield per plant/season (ml) and essential oil yield per feddan/season (l) to compost fertilization and some antioxidants during both seasons (2021/2022 and 2022/2023).

Antioxidant treatments (B)	Compost fertilization level, ton/feddan (A)									
	0.0	4	8	12	Mean (B)	0.0	4	8	12	Mean (B)
	First season (2021/2022)					Second season (2022/2023)				
	Essential oil yield per plant/season (ml)									
Control	0.066	0.085	0.085	0.096	0.083	0.068	0.094	0.097	0.134	0.098
AA (1 ml/l)	0.076	0.099	0.097	0.116	0.097	0.094	0.106	0.130	0.142	0.118
AA (2 ml/l)	0.081	0.108	0.118	0.160	0.117	0.119	0.131	0.162	0.188	0.150
SAE (1.5 ml/l)	0.094	0.120	0.142	0.189	0.136	0.160	0.192	0.217	0.227	0.199
SAE (3 ml/l)	0.105	0.132	0.188	0.202	0.157	0.210	0.237	0.252	0.265	0.241
Vit. E (100 ppm)	0.127	0.162	0.240	0.246	0.194	0.268	0.302	0.326	0.342	0.309
Vit. E (200 ppm)	0.116	0.146	0.213	0.219	0.174	0.247	0.276	0.278	0.295	0.274
Mean (A)	0.095	0.122	0.155	0.175	0.137	0.166	0.191	0.209	0.228	0.199
$LSD_{0.05}$	A: 0.021		B: 0.014		AB: 0.028	A: 0.022		B: 0.015		AB: 0.030
	Essential oil yield per feddan/season (l)									
Control	6.159	7.808	9.092	11.393	8.613	6.232	8.899	10.623	13.848	9.901
AA (1 ml/l)	7.489	10.852	11.583	13.959	10.971	8.489	11.017	13.030	14.954	11.873
AA (2 ml/l)	8.266	12.429	14.560	17.852	13.277	10.782	13.392	17.006	22.086	15.816
SAE (1.5 ml/l)	9.674	14.208	17.208	20.781	15.468	13.545	17.944	22.793	26.339	20.155
SAE (3 ml/l)	11.129	15.861	21.081	22.820	17.723	17.735	22.132	27.491	30.856	24.553
Vit. E (100 ppm)	13.885	20.081	26.845	28.841	22.413	22.476	33.594	36.073	40.181	33.081
Vit. E (200 ppm)	12.621	18.015	23.930	25.113	19.920	20.479	25.715	30.462	33.977	27.658
Mean (A)	9.889	14.179	17.757	20.109	15.483	14.248	18.956	22.497	26.034	20.434
$LSD_{0.05}$	A: 3.554		B: 3.011		AB: 6.022	A: 4.701		B: 4.663		AB:9.326

Where: AA (amino acids), SAE (sea algae extract) and Vit. E (vitamin E)

phosphorus is crucial for the formation of these compounds (Asghari *et al*., 2015). Consequently, enhancing the quantity of compost leads to a greater production of EO in the plant's vegetative parts, as it facilitates and improves nitrogen and phosphorus absorption, both of which are integral to the ingredients of essential oils (Anwar *et al*., 2005).

In agreement with our results were those obtained by Kazeminasab *et al*. (2016), Razipour *et al*. (2016) and Rahmanian *et al*. (2022) on lemon balm, Adholeya and Prakash (2004) and Valiki *et al*. (2015) on rosemary, Rahimpoor and Fallah (2018) on basil, Khater *et al*. (2020) and Abdou and Badr (2022) on caraway, and Abdou *et al*. (2020) on fennel.

Data presented in Tables (1 and 2) pointed out that essential oil percent and yield per plant per cut of lemon balm were noticeably augmented due to the all six used antioxidants treatments (amino acids, sea algae extract and vitamin E, each at 2 concentrations) relative to the check treatment through the three cuts during both seasons. Moreover, the calculation of EO yield per plant or per feddan per season were considerably increased by all used antioxidant treatments (Table, 3). Where, the highest yield of essential oil per feddan in the first season in a descending order were 28.841, 25.113, 22.820, 20.781, 17.852, 13.959 and 11.393% due to vitamin E at 100 ppm, vitamin E at 200 ppm, sea algae at 3 ml/l, sea algae at 1.5 ml/l, amino acids at 2 ml/l, amino acids at 1 ml/l and control treatment. The same trends were detected in the second season (Table, 3).

It is impossible to produce one common mode of action of all antioxidants, simplicity, it was suggested that the effect of antioxidants in plants is a consequence of their influence on plant metabolism. They synthesis natural hormones, sometimes increasing their activity, facilitating the uptake of nutrients, enhancing biochemical processes in plant, improving the growth and consequently, there quantity and quality (Rafiee *et al*. 2016 and Sun *et al*. 2024).

In agreement with our results were those reported by Ismail (2008) and Ayyat *et al*. (2021) on black cumin, Abdou *et al*. (2012) on mint, Abdou *et al*. (2014 and 2017) on *Ocimum basilicum*, and Ali and Hussein (2019) on Senna coffee plant for vitamin E. In addition, Salama and Yousef (2015) and El-Naggar *et al*. (2020) on *Ocimum spp.*, Eisa (2016), on sweet fennel, Nassar *et al*. (2020), on *Origanum majorana* L., Al-Khamas and Al-Rubaie (2023) on *Rosmarinus officinalis* and El-Ziat *et al*. (2024) on *Tagetes patula* L. concerning sea algae. Also, Ahmed (2009) on *Melissa officinalis* L., Hendawy *et al*. (2015), on peppermint, Salama and Yousef (2015) on *Ocimum sanctum* L., Mohamed *et al*. (2020) on *Origanum majorana*, and Al-Fraihat *et al*. (2023) on *Rosmarinus officinalis*, with regard to the influence of amino acids.

The combination effect between the main and sub-plots treatments was significant for EO percentage and yield in all cases. The highest values overall were obtained from plants fertilized with 12 or 8 ton/fed compost and sprayed with vitamin E (100 ppm).

2. Chemical composition:

Data listed in Tables (4 and 5) pointed out that a noticeable enhancement in photosynthetic pigments contents (chl. a, chl. b and carotenoids in fresh leaves) and some macro-elements (N, P and K % in dry leaves) in the third cut were found as a result of compost fertilization levels in each of the two seasons comparing with the control. The application of compost at a rate of 12 tons per feddan proved to be more beneficial for plant growth compared to other treatments, including the control.

Compost application has been recognized to improve the physical and chemical properties of most soils as it is rich in nutritional elements resulting in more growth and processes in plants including photosynthetic contents. (Kranz *et al*., 2020 and Ali and Al-Bakkar, 2021). Moreover, supplying plants with organic matter improves soil nutrition status in the root zone, consequently enhancing absorption and uptake of nutrients.

Similar results were mentioned by Kazeminasab *et al*. (2016) and Razipour *et al*. (2016) on *Melissa officinalis*, Khater *et al*. (2020) and Abdou and Badr (2022) on caraway, Esmaielpour *et al*. (2018) on savory, Abdou *et al*. (2020) on fennel, Abdou *et al*. (2023a) on cineraria, and Abdou *et al*. (2023b) on calendula.

Concerning the effect of antioxidants, all the six used treatments significantly enhanced the three tested pigments contents (Table, 4) and macro-nutrients percentages relative to the control (Table, 5). Vitamin E was more effective than either amino acids or sea algae.

The improvement role of antioxidants substances on pigments contents may be attributed to direct or indirect roles such as the activity of antioxidant enzymes, accessory pigments, calcium, potassium, and magnesium (Farouk, 2011 and Semida *et al*., 2016). Antioxidants enhanced the physiological processes in plant, consequently, increasing elements sucking and intake, reflecting in great nutrient content.

Similar results were obtained by Abdou *et al*. (2013) and Abdou and Badr (2022) on caraway, Abdou *et al*. (2017) on sweet basil, Abdou *et al*. (2019) on cumin and Ayyat *et al*. (2021) on black cumin, concerning vitamin E. Also, Shehata *et al*. (2011), on celeriac, Eisa (2016) on sweet fennel, Alimaleki and Asadi-Gharneh (2020) on zarrin-giah, Al-Mohammadi and Alshaheen (2022) on rosemary and El-Ziat *et al*. (2024) on French marigold regarding sea algae and Majkowska-Gadomska *et al*. (2022) on lemon balm, El-Attar and Ashour (2016) on chamomile, Mohamed *et al*. (2020) on *Origanum majorana* and Al-Fraihat *et al*. (2023) on *Rosmarinus officinalis* for the effect of amino acids.

The effect of interaction between main and sub-plots treatments was significant for photosynthetic pigments content and N, P and K % in both seasons (Tables, 4 and 5). The highest values were achieved by fertilizing plants with 8 or 12 ton/fed compost and sprayed with vitamin E.

Table 4. Response of chlorophyll a, b and carotenoids contents (mg/g f.w.) of *Melissa officinalis* to compost fertilization and some antioxidants throughout the third cut during both seasons (2021/2022 and 2022/2023).

Antioxidant treatments (B)	Compost fertilization level, ton/feddan (A)									
	0.0	4	8	12	Mean (B)	0.0	4	8	12	Mean (B)
	First season (2021/2022)					Second season (2022/2023)				
	Chlorophyll a content (mg/g f.w.)									
Control	2.666	2.768	2.819	2.840	2.773	2.674	2.776	2.827	2.849	2.782
AA (1 ml/l)	2.754	2.859	2.910	2.936	2.865	2.762	2.868	2.919	2.945	2.873
AA (2 ml/l)	2.844	2.946	2.993	3.012	2.949	2.853	2.955	3.002	3.021	2.958
SAE (1.5 ml/l)	2.948	3.046	3.096	3.128	3.055	2.957	3.055	3.105	3.137	3.064
SAE (3 ml/l)	3.045	3.146	3.195	3.228	3.154	3.054	3.155	3.205	3.238	3.163
Vit. E (100 ppm)	3.138	3.237	3.286	3.304	3.241	3.147	3.247	3.296	3.314	3.251
Vit. E (200 ppm)	3.126	3.226	3.254	3.287	3.223	3.135	3.236	3.264	3.297	3.233
Mean (A)	2.932	3.033	3.079	3.105		2.940	3.042	3.088	3.114	
$LSD_{0.05}$	A: 0.040		B: 0.020		AB: 0.040	A: 0.050		B: 0.025		AB: 0.050
	Chlorophyll b content (mg/g f.w.)									
Control	0.869	0.903	0.920	0.927	0.904	0.871	0.905	0.922	0.929	0.907
AA (1 ml/l)	0.898	0.933	0.950	0.959	0.935	0.901	0.936	0.953	0.962	0.938
AA (2 ml/l)	0.928	0.962	0.978	0.984	0.963	0.931	0.965	0.981	0.987	0.966
SAE (1.5 ml/l)	0.963	0.995	1.012	1.023	0.998	0.966	0.998	1.015	1.026	1.001
SAE (3 ml/l)	0.995	1.029	1.045	1.056	1.031	0.998	1.032	1.048	1.059	1.034
Vit. E (100 ppm)	1.026	1.059	1.075	1.081	1.060	1.029	1.062	1.079	1.085	1.064
Vit. E (200 ppm)	1.022	1.055	1.065	1.076	1.054	1.025	1.058	1.068	1.079	1.058
Mean (A)	0.957	0.991	1.006	1.015		0.960	0.994	1.009	1.018	
$LSD_{0.05}$	A: 0.022		B: 0.004		AB: 0.008	A: 0.014		B: 0.005		AB: 0.010
	Carotenoids content (mg/g f.w.)									
Control	0.919	0.953	0.970	0.977	0.954	0.922	0.956	0.974	0.981	0.958
AA (1 ml/l)	0.948	0.983	1.000	1.009	0.985	0.952	0.987	1.004	1.013	0.989
AA (2 ml/l)	0.978	1.012	1.028	1.034	1.013	0.982	1.016	1.032	1.038	1.017
SAE (1.5 ml/l)	1.013	1.045	1.062	1.073	1.048	1.017	1.050	1.066	1.077	1.052
SAE (3 ml/l)	1.045	1.079	1.095	1.106	1.081	1.049	1.083	1.099	1.110	1.085
Vit. E (100 ppm)	1.076	1.109	1.125	1.131	1.110	1.080	1.113	1.130	1.136	1.115
Vit. E (200 ppm)	1.072	1.105	1.115	1.126	1.104	1.076	1.110	1.119	1.130	1.109
Mean (A)	1.007	1.041	1.056	1.065		1.011	1.045	1.061	1.069	
$LSD_{0.05}$	A: 0.031		B: 0.004		AB: 0.008	A: 0.033		B: 0.004		AB: 0.008

Where: AA (amino acids), SAE (sea algae extract) and Vit. E (vitamin E)

Table 5. Response of nitrogen, phosphorus and potassium (%) in dry leaves of *Melissa officinalis* to compost fertilization and some antioxidants throughout the third cut *during both seasons (2021/2022 and 2022/2023).*

Antioxidant treatments (B)	Compost fertilization level, ton/feddan (A)									
	0.0	4	8	12	Mean (B)	0.0	4	8	12	Mean (B)
	First season (2021/2022)					Second season (2022/2023)				
					Nitrogen (%)					
Control	2.42	2.63	2.75	2.87	2.67	2.47	2.68	2.81	2.93	2.72
AA (1 ml/l)	2.54	2.76	2.87	3.01	2.80	2.59	2.82	2.93	3.07	2.85
AA (2 ml/l)	2.64	2.85	2.93	3.08	2.88	2.69	2.91	2.99	3.14	2.93
SAE (1.5 ml/l)	2.77	2.87	3.02	3.14	2.95	2.83	2.93	3.08	3.20	3.01
SAE (3 ml/l)	2.85	2.95	3.11	3.21	3.03	2.91	3.01	3.17	3.27	3.09
Vit. E (100 ppm)	3.13	3.30	3.42	3.46	3.33	3.19	3.37	3.49	3.53	3.39
Vit. E (200 ppm)	2.99	3.14	3.26	3.30	3.17	3.05	3.20	3.33	3.37	3.24
Mean (A)	2.76	2.93	3.05	3.15		2.82	2.99	3.11	3.22	
$LSD_{0.05}$	A: 0.11		B: 0.005		AB: 0.10	A: 0.15		B: 0.08		AB: 0.16
					Phosphorus (%)					
Control	0.44	0.49	0.52	0.55	0.50	0.45	0.50	0.53	0.56	0.51
AA (1 ml/l)	0.46	0.51	0.55	0.58	0.53	0.47	0.52	0.56	0.59	0.53
AA (2 ml/l)	0.49	0.56	0.6	0.63	0.57	0.50	0.57	0.61	0.64	0.58
SAE (1.5 ml/l)	0.52	0.58	0.65	0.72	0.62	0.53	0.59	0.66	0.73	0.62
SAE (3 ml/l)	0.55	0.63	0.7	0.75	0.66	0.56	0.64	0.71	0.76	0.67
Vit. E (100 ppm)	0.61	0.7	0.78	0.83	0.73	0.62	0.71	0.79	0.84	0.74
Vit. E (200 ppm)	0.58	0.67	0.73	0.78	0.69	0.59	0.68	0.74	0.79	0.70
Mean (A)	0.52	0.59	0.65	0.69		0.53	0.60	0.65	0.70	
$LSD_{0.05}$	A: 0.05		B: 0.03		AB: 0.06	A: 0.06		B: 0.02		AB: 0.04
					Potassium (%)					
Control	1.65	1.67	1.69	1.71	1.68	1.62	1.64	1.66	1.68	1.65
AA (1 ml/l)	1.73	1.80	1.85	1.89	1.82	1.70	1.76	1.81	1.85	1.78
AA (2 ml/l)	1.79	1.86	1.91	1.94	1.88	1.75	1.82	1.87	1.90	1.84
SAE (1.5 ml/l)	1.84	1.87	1.94	1.96	1.90	1.80	1.83	1.90	1.92	1.86
SAE (3 ml/l)	1.89	1.91	1.96	1.98	1.94	1.85	1.87	1.92	1.94	1.90
Vit. E (100 ppm)	1.95	1.97	1.98	2.01	1.98	1.91	1.93	1.94	1.97	1.94
Vit. E (200 ppm)	1.90	1.93	1.97	1.99	1.95	1.86	1.89	1.93	1.95	1.91
Mean (A)	1.82	1.86	1.90	1.93		1.79	1.82	1.86	1.89	
$LSD_{0.05}$	A: 0.04		B: 0.03		AB: 0.06	A: 0.0.03		B: 0.02		AB: 0.04

Where: AA (amino acids), SAE (sea algae extract) and Vit. E (vitamin E)

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تأثير معاملات الكمبوست وبعض مضادات الأكسدة على إنتاج الزيت وبعض المكونات الكيميائية للميليسا

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تم إجراء هذا البحث خلال موسمي ٢٠٢٢/٢٠٢١ و ٢٠٢٣/٢٠٢٢ بمشتل نباتات الزينة، كلية الزراعة، جامعة المنيا، مصر بهدف دراسة تأثير الكمبوست وبعض مضادات الأكسدة (الأحماض الأمينية، ومستخلص الأعشاب البحرية، وفيتامين هـ) على إنتاجية الزيت وبعض المكونات الكيميائية لنبات الميليسا. أظهرت النتائج أن جميع الصفات المدروسة: النسبة المئوية للزيت العطري ومحصول الزيت للنبات لكل قطفة قد زادت بشكل ملحوظ نتيجة تسميد النباتات بالمستويات الثلاثة من الكمبوست مقارنة بالكنترول خلال القطفات الثلاثة في كلا الموسمين. فضلاً عن ذلك، فقد زادت جميع الصفات المذكورة أعلاه من القطفة الأولي حتى القطفة الثالثة. كما زادت إنتاجية الزيت العطري للنبات/موسم والفدان/موسم، وكذلك زاد محتوى الكلوروفيل أ، ب والكاروتينويدات ونسبة NPK بشكل ملحوظ مع تسميد النباتات بالكمبوست (المستويات الثلاثة المستخدمة). وقد تم الحصول على أعلى القيم من استخدام ١٢ طن كمبوست/فدان، تليها ٨ أطنان كمبوست/فدان، بدون فروق معنوية بينهما في معظم الحالات. أدت إضافة الأحماض الأمينية والطحالب البحرية وفيتامين هـ، كلٍ بالتركيزات المستخدمة، إلى تحسن ملحوظ في جميع المقاييس المذكورة سابقاً عند مقارنتها بمجموعة التحكم في كلا الموسمين. وفي هذا الشأن، أظهر فيتامين هـ بالتركيز المنخفض (١٠٠ جزء في المليون) تأثيرات متفوقة بشكل خاص. وكانت أفضل معاملة تفاعل هي امداد النباتات بالكمبوست بمعدل ١٢ أو ٨ أطنان/فدان والرش بفيتامين هـ ١٠٠ أو ٢٠٠ جزء في المليون أو الطحالب البحرية بمعدل ٣ مل/لتر للحصول على أعلى نسبة ومحصول للزيت العطري لكل نبات وللفدان من الميليسا.